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Exploring the Academic Choices of Undergraduates: Factors Influencing the Decision to Major in Science

by

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The undersigned certify that they have read, and recommend to the Faculty of Graduate Studies for acceptance, a thesis entitled "Exploring the Academic Choices of Undergraduates: Factors Influencing the Decision to Major in Science" submitted by Rebecca Johnstone in partial fulfilment of the requirements for the degree of Master of Arts.

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ABSTRACT

Researchers studying the science pipeline have explored differences between science and social science majors and factors that influence the decision to major in science. My results highlight the often overlooked fact that differences between science and social science majors do not necessarily translate into significant effects in models predicting the probability of majoring in science. They also highlight the importance of testing these models with data on men and women in science and nonscience fields. I found that gender may not be as important an influence on the decision to pursue science as some researchers suggest. I also found that our understanding of the factors that influence the decision to pursue science is improved by taking seriously the temporal and contextual elements of the science pipeline.

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DEDICATION

To my parents, Lis and Stuart

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CHAPTER ONE:

INTRODUCTION

Like their counterparts in other highly industrialized societies, Canadians inside and outside government at all levels continue to stress the link between industrial competitiveness and the availability of individuals with advanced knowledge in science and technology. A recent Premiers' Council (1993) concluded that to remain competitive at the global level, we need a pool of well-trained individuals. But as recent studies make clear, university enrollment in science is declining (Lewko, Hein, Garg, and Tesson,1993; Pool, 1990). Not surprisingly, then, policy analysts and researchers have called for a better understanding of the factors that influence the decision to pursue science.

Borrowing Widnall's (1988) pipeline analogy, I conceptualize the pursuit of science as an ongoing decision-making process. At multiple points along this pipeline individuals make decisions that may lead them to pursue science. These decisions are made in high school, at the undergraduate and graduate levels in university, and throughout careers. Current research has found that at each decision-making point, fewer and fewer individuals decide to continue on in science. Most high school students have some science training. But as we move to the undergraduate level, statistics show that many students who had expressed an interest in majoring in science while in high school do not choose an undergraduate science major (Farmer, Wardrop, Anderson, and Risinger, 1995). At successively higher levels, even smaller numbers of science students decide to continue pursuing science (Pool, 1990; Widnall, 1988). The negative implications of these decisions for Canada's pool of scientists are exacerbated by the fact that students who pursue undergraduate science degrees are not necessarily pursuing a science career (Nevitte, Giddins and Codding, 1988). Instead, some use a science degree as a "springboard" to non-science occupations.

Research on women in science suggests that women leave science at far higher rates than men (Brush, 1991; Ferry, 1982; Primack and O'Leary, 1993; Zuckerman and Cole, 1975). In the past, much of this research focussed on mechanisms that kept women from continuing their science studies. The emphasis, therefore, was on exit points along the pipeline and the factors that accounted for them. More recently, however, researchers have shifted their attention to the factors that influence a person's decision to pursue science.

A considerable amount of research has been conducted on the decision to pursue science. My reading of the literature suggests that these studies can be categorized into four strands of research: (1) Women in Science, (2) Men and Women in Science, (3) Women's Academic/Career Choices, and (4)

Men's and Women's Academic/Career Choices. These strands represent four different approaches to understanding the decisions of men and women to major or pursue careers in science. Research in each category has explored all points along the science pipeline: high school students, undergraduate students, graduate students, post-doctoral students, and those working in science-related careers. Taken together, then, these studies have identified a series of factors that influence the decision to pursue a degree or career in science. My thesis explores factors that influence the decision to choose an undergraduate science major. But because research on all points of the pipeline is relevant, my overview of these four strands of research covers earlier and later decision-making points.

Women in Science

Much of the Women in Science literature has focused on gender differences in composition of the sciences (Ferry and Moore, 1982; Frieze, Whitley, Hanusa, and McHugh, 1984; Kelly, 1982; Primack and O'Leary, 1993; Rosser, 1993; White, 1970; Zuckerman and Cole, 1975). Because it asks "Why girls (women) don't do science?" (Ferry, 1982), this research stresses barriers that deter women from pursuing science at all points on the pipeline. It suggests that the "Culture of Science" remains the major obstacle to women entering science at the same rate as men. This culture reflects and contributes to the male domination of science. This historic domination by men is reflected in both the pedagogy of science (Kelly, 1982; Rosser, 1993) and in science stereotypes (Acker and Oatley, 1993; Frieze et al., 1984). Pedagogical strategies include the use of examples in science classes that alienate women. Kelly (1982) noted that the "Men of Science" series in British schools suggests that women made no important contributions to science, thus perpetuating the notion that there is no place for women in this field. Other researchers have highlighted the concentration of male-related references in text books and classroom experiments (guns, cars, football, and machinery) (Brush, 1991; Kelly, 1982).

Stereotypes about science and scientists instill in women and men the idea that science is not for women. Frieze et al. (1984) suggest that at the same time that scientists are portrayed as "rational, objective, intelligent, and insightful", women are characterized as "emotional and irrational". They also note that because both male and female students expect scientists to have these qualities, these stereotypes increase the probability that men will choose science but have the opposite effect for women.

This strand of research also explores strategies for overcoming these obstacles. It points to the importance of encouragement to pursue science at all points on the pipeline. Researchers also note the importance of role models. According to them, encouragement and role models are especially important for women because they are entering a field that is not "legitimately" theirs. Female students in science face obstacles that can be overcome with sufficient encouragement and role models, in particular female role models, who can help junior women overcome the cultural impediments of science (Primack and O'Leary, 1993; Rosser, 1993; White, 1970). As women who have conquered or at least survived the obstacles of science, these role models not only offer support and guidance to other women, but also provide living proof to up-and-coming female science students that they can become scientists too (Etzkowitz, Kemelgor, Neuschatz, Uzzi, and Alonzo, 1994).

In sum, the Women in Science strand of research has highlighted the obstacles or "cumulative disadvantages" (Primack and O'Leary, 1993) that women face when pursuing science from the high school level to the career level. Most of these obstacles are products of a "Culture of Science" in which science takes on the characteristics and qualities of men. Studies in this strand emphasize the important role that encouragement from others plays in attempts to overcome these obstacles. By establishing that different barriers may have more serious consequences at different times in a student's life, it highlights the importance of taking seriously all points on the science pipeline. The major limitation of this research is that it has focussed exclusively on women. As a result, these researchers are unable to draw any conclusions about the differences between men and women in science. The Men and Women in Science strand of research attempts to fill this gap.

Men and Women in Science

Research on men and women in science shifts the focus from barriers to women in science to gender differences in science. The key question now becomes "Why don't girls (women) do science at the same rate as boys (men)?". To answer this question, researchers have compared men and women in science at all points along the pipeline (Acker and Oatley, 1993; Lewko et al., 1993; Lips, 1992; Morgan, 1992; Nevitte et al.,1988; Sonnert and Holton, 1996; Ware and Lee, 1988; Ware, Steckler and Lesserman, 1985). And, while it continues to explore barriers to pursuing science, it also examines factors that facilitate this pursuit.

Most of this research has been conducted at the high school and undergraduate levels. High school experiences are key facilitating factors or entry points into the science pipeline for men and women. High levels of preparation and achievement in high school mathematics and science courses are consistently shown to have a positive impact on choice of an undergraduate science major (Chipman and Thomas, 1987; Deboer, 1984,1986; Lewko et al.,1993).

This strand of literature also explores gender differences in intellectual orientations (e.g., mathematics self-efficacy and science self-efficacy) and their implications for choice of undergraduate major (Deboer, 1986; Sonnert and Holton, 1996). It is argued that female students have lower levels of self-efficacy in both mathematics and science and, therefore, are less likely than their male counterparts to pursue science (Deboer, 1986).

In sum, this strand of research expands the scope of the Women in Science literature to include factors that lead men to pursue a degree or career in science. It also focusses less on the barriers and instead highlights facilitating factors, thus providing a more positive representation of the science pipeline. It is limited, however, by its exclusive focus on science. The question "Are the factors identified by this literature unique to science?" remains unanswered. One strategy to answer this question has generated the Women's Academic/Career Choice literature.

Women's Academic/Career Choices

Understanding the academic/career choices of women is important because it helps to identify factors that may lead them to declare a major in science. This strand of research has concentrated on women who make nontraditional major and/or career choices, including science (Almquist, 1974; Ethington and Wolfe, 1988; Fassinger, 1990; Hollinger, 1983). The traditional-nontraditional distinction suggests that there are certain sex-appropriate majors and careers for women, and that there are differences between those women who do and do not pursue them. Most of this research has focussed on three areas of these students' lives: their family background characteristics, the amount of encouragement received, and their sex-role attitudes (Ethington and Wolfe, 1988; Houser and Garvey, 1985; Lemkau, 1983; O'Donnell and Anderson, 1978).

The literature stresses that nontraditional female students tend to have particular family background characteristics, such as more highly educated parents and mothers who work full-time (Fitzpatrick and Silverman, 1989; Lemkau, 1983: O'Donnell and Anderson, 1978). They also receive more encouragement to pursue nontraditional majors and careers than their counterparts in more traditional fields. The primary distinguishing feature, however, appears to be sex-role attitudes. Not surprisingly, women who make nontraditional academic and career choices have less traditional sex-role attitudes than those who make traditional choices (Almquist, 1974; Fassinger, 1990; Sandberg, Ehrhardt, Mellins, Ince, and Meyer-Bahlburg, 1987). The latter express stronger beliefs in sex-appropriate behaviour, including sex-appropriate majors and careers. The former, in contrast, have "broader conceptualizations of masculine and feminine roles" (Lemkau, 1983:163) which results in a broader range of acceptable major and career choices.

In sum, this strand of research identifies family background, encouragement, and sex-role attitudes as factors that either encourage or inhibit women from choosing nontraditional majors and/or careers, including science. But once again men have been left out of the picture and readers are left wondering if the same factors lead men to majors and careers in science.

<u>Men's and Women's Academic/Career Choices</u>

The final strand of research explores gender differences in academic choices. Like the "Men and Women in Science" research, this work focuses on gender differences in the factors that affect the decision of high school and undergraduate students (Brooks and Betz, 1990; Gati, Osipow, and Givon, 1995; Kelly, 1976; Wilson and Boldizar, 1990), but here the range of outcomes includes nonscience alternatives.

This research shows that men and women tend to make decisions that reflect traditional gender roles in society (Broverman, Vogel, Broverman, Clarkson, And Rosenkrantz, 1972). Researchers argue that the gender socialization process has led to a "cultural milieu" of gender-structured academic and career choices (Nevitte et al.,1988). As a result, most men enter business or science-related majors and careers, while women pursue the softer, more nurturing majors and careers.

These studies have also paid attention to the impact of gender differences in work values on academic and career decisions. Most start from the position that men tend to value extrinsic rewards, whereas women value intrinsic rewards more highly (Almquist, 1974; Gati et al.,1995).

Factors Influencing the Decision to Major in Science

Taken together, these four strands of research provide the backdrop for my analysis of the factors that influence an undergraduate to select a science major. Each strand identifies a series of factors that either increase or decrease the probability of pursuing science at different points along the pipeline. Collectively, these factors fall into six interrelated, yet distinct, categories: Family Background, High School Experiences, Student Interests, Sex-Role Attitudes, Intellectual Orientation, and Encouragement to Pursue Science.

Two things are clear from this review. First, decisions made at the undergraduate point on the pipeline are particularly consequential for careers in science. At the same time that they build on high school experiences, they have long-term implications for students and for the Canadian labour force more generally. Second, studies at this point in the pipeline that include men and women in science and nonscience majors are relatively rare. To begin to fill this gap, I explore the academic choices of undergraduates by developing and testing a series of hypotheses that: (1) examine the differences between science and social science majors and (2) explore the factors that influence the decision to major in science. The first set of hypotheses predict the differences in characteristics, in terms of mean differences, that exist between science and social science majors. The second set of hypotheses looks at differences in effects of the variables on the probability of majoring in science. This approach is unique because it is able to examine whether differences in the levels (e.g., amount of science preparation) translate into good predictors of a science major. Although few studies (Ware and Lee, 1988) have taken this approach, it has been shown to provide a clearer picture of the factors involved in academic choices.

I set out my predictions for the differences between science and nonscience majors in Chapter Two. In Chapter Three, I develop models to predict the probability of majoring in science without gender interactions (Model One), and with gender interactions (Model Two). In Chapter Four, I discuss my sample, measures, and the data analytic procedures that are used to test my hypotheses about differences in levels and differences in effects. My presentation of results in Chapter Five is organized around the six categories of factors identified in Chapter One. Finally, in Chapter Six, I highlight key findings and explore their importance for ongoing research on the science pipeline.

CHAPTER TWO:

COMPARING SCIENCE AND SOCIAL SCIENCE MAJORS:

A REVIEW OF THE LITERATURE

Research on academic choices has established the importance of the six sets of factors identified in Chapter One. The first part of my thesis builds on this research and asks "Do differences exist in the levels of these factors for science and social science majors?" (Ethington and Wolfe, 1988; Goldman and Hewitt, 1976; Lewko et al.,1993; Nevitte et al., 1988; Ware and Lee, 1988; Pathways Project, 1993). In the discussion that follows, I use these six categories to set out a series of predictions about differences between science and social science majors.

Family Background

Research on men's and women's academic/career choices has used status attainment literature to frame studies of the implications of parental achievements in education, occupation, and income (Bielby, 1981; Blau and Duncan, 1967; Featherman, 1981; Featherman and Hauser, 1974; Featherman, Jones and Hauser, 1975; Sewell and Hauser, 1980). Of particular interest to the academic choices research is the educational and occupational achievement of fathers and mothers. Status attainment researchers have established that parents' educational attainment affects their children's academic attainment (Blau and Duncan, 1967; Featherman, Jones, and Hauser, 1975; Knottnerus, 1987). Early status attainment research focussed on the consequences of fathers educational attainment for that of their sons (Blau and Duncan, 1967). Mothers and their daughters were often left out because too few women entered university and attained high levels of education. Women now comprise approximately half of the student population. As a result status attainment models are increasingly recognizing that mothers' educational attainment also has important implications for their sons and daughters (Pathways Report, 1993).

It has been shown that children who have parents with high educational attainment tend to aspire to higher educational levels (Sewell, Featherman, and Hauser, 1980). In their study of high school students, Lewko et al. (1993) found that gifted science students had more highly educated parents than the general population of students. At the university level in general, however, most students have highly educated parents (Ware et al., 1985). It is not surprising, then, that the Pathways Project (1993) did not find significant differences in parental educational levels for science and nonscience majors. I follow it and predict that there will be no difference in fathers' educational attainment for science and social science majors (Hypothesis 1). I also predict that there will be no difference in mothers' educational attainment for science and social science majors (Hypothesis 2).

Like its education counterpart, early status attainment research on occupational attainment explored the relationship between father's and son's occupations (Kelly, 1976; Sewell and Hauser, 1980). Research since then has established the relevance of this connection for mothers and daughters as well (Pathways Project, 1993). Academic choices applications of these status attainment models have produced mixed results. In an early study of family background and subject specialization, Kelly (1976) found although sons often followed in their father's occupational footsteps, this pattern did not hold for science-related occupations. Researchers who have replicated Kelly's study, however, found that science students often follow their parents into science (Nevitte et al.,1988; Pathways Project, 1993). Nevitte et al.(1988) suggest that parents in science act as role models for their children. Their findings show that father's occupation clearly differentiated women in science from women in other academic disciplines. The Pathways Project (1993) also found that almost half of their science students had at least one of their parents working in science, health, or engineering jobs. Based on these findings, I predict that science majors are more likely to have fathers working in science-related occupations than social science majors (Hypothesis 3). I also predict that science majors are more likely to have mothers working in science-related occupations than social science majors (Hypothesis 4).

High School Experiences

The importance of high school experiences in mathematics and science is well established in all strands of the literature on academic choices (Chipman and Thomas, 1987; Deboer, 1984; Fassinger, 1990; Lewko et al., 1993; Lips, 1992; Turrittin, Anisef and MacKinnon, 1983). To cope with university science courses, students must have the necessary background, exposure and talent in mathematics and science. The following quotation from Lovely (1987 as cited in the Pathways Project, 1993:29) highlights the importance of high school experiences: "students who come to college unprepared in science and mathematics or lacking ability in those areas, are unlikely to be able to manage college level courses in these fields". My research explores these high school experiences by examining differences in mathematics and science preparation and achievement.

Ware and Lee (1988) compared science and nonscience majors and found that science majors had completed more mathematics and science courses than their nonscience counterparts. This observation is consistent with Lewko et al.'s (1993) findings that gifted high school science students had taken more science courses than students in the nonscience group and that members of the science group intended to take more science-related courses in the future. Two predictions follow. First, science majors will have completed more mathematics courses than social science majors (Hypothesis 5). Second, science majors will have completed more science courses than social science majors (Hypothesis 6).

Turning to mathematics and science achievement, most of the research on high school achievement has explored gender differences in science majors (Deboer, 1986; Erickson and Erickson, 1984). One exception to this focus on gender differences is the Pathways Project (1993). It reported nonscience majors had lower science grades than science majors. It also found that seven percent of the students who had switched from a science major to a nonscience major cited poor grades in science courses as a reason for switching. Based on these observations, I expect that the science majors will have higher mathematics and science grades than social science majors (Hypothesis 7).

Student Interests

Researchers exploring the differences between science and nonscience majors have established the importance of level of interest in science, job aspirations, and job rewards (Almquist, 1974; Lewko et al., 1993; Lips, 1992; Pathways Project, 1993; Ware et al.,1985; Ware and Lee, 1988; Zuckerman and Cole, 1975). One of their most consistent findings is that science majors express more interest in science than nonscience majors (Ware et al.,1985). In the Pathways Project (1993), students majoring in science reported having above average interest in science more often than nonscience majors. This pattern also holds for high school students. In one study "two-thirds of the science group reported a high interest in science as compared to the one third of nonscience students who expressed an interest in science" (Lewko et al.,1993:76). Members of the science group also tended to have more favourable attitudes toward science and participated more often in science activities than their nonscience counterparts. Based on this research, I predict that science majors will have more interest in science than social science majors (Hypothesis 8).

Having an interest in a particular subject often leads people to pursue careers in their areas of interest. Not surprisingly, then, studies have found that science majors are more likely to aspire to science-related careers than nonscience majors (Lewko et al.,1993). As Goldman and Hewitt (1976) point out, because career aspirations have consequences for undergraduate students, those who are interested in a science-related career usually major in science at university. Twenty-two percent of the participants in the Pathways Project (1993) reported that they chose science because they had a career interest in that subject. But this does not mean that all science majors are interested in science-related careers (Farmer et al., 1995). Nevitte et al.(1988) found that some men majoring in science wanted careers in business and some women wanted nurturing careers, such as teaching. Despite these exceptions, I predict that science majors will have more interest in a science-related career than social science majors (Hypothesis 9).

If career aspirations are related to the academic route students have chosen to follow, then the rewards or work values associated with these careers may also differ by academic choice. Work values are usually divided into extrinsic job rewards and intrinsic job rewards. Extrinsic job rewards encompass such things as money (Gati et al., 1995) prestige and job openings (Lips, 1992). Intrinsic job rewards include working with people (Almquist, 1974; Gati et al., 1995), satisfying personal interests, the freedom to make decisions, and enjoyment (Lips, 1992). My research examines the implications of intrinsic rewards.

Although most of this research on intrinsic rewards has examined gender differences, the Pathways Project (1993) explored differences across majors. This focus is interesting because of its links with the "Culture of Science". This culture and its accompanying stereotypes help to perpetuate the view that "science is a haven for nerdy, nonsociable individuals" (Lips, 1992). This view implies that science students who accept these stereotypes may be less interested in working with people in their subsequent careers than nonscience majors. The Pathways Project (1993), however, did not find any significant differences in preference for working with people between the science and nonscience majors. I argue that because the focus of the social sciences tends to be on people and their behaviours, and because social scientists are more likely to accept negative science stereotypes, social science majors will have more interest in working with people than science majors (Hypothesis 10).

<u>Sex-Role Attitudes</u>

Much attention in all four strands of research has been given to students' sex-role attitudes and how they differ by academic choice (Almquist, 1974; Fassinger, 1990; Lips, 1992; Morgan, 1992; Nevitte et al.,1988; Pathways Project, 1993; Sandberg et al., 1987; Sonnert and Holton, 1996). This research has emphasized the global sex-role attitudes of students and their science-specific sex-role attitudes. Global sex-role attitudes express the extent to which an individual believes in traditional sex-roles (e.g., men are the breadwinners and women stay home to look after the children). Science-specific sex-role attitudes express beliefs about the roles of men and women in the domain of science. Because this domain is largely occupied by men, it raises issues, particularly for women, about the compatibility of a career in science and having a family and whether women belong in science.

Nevitte et al. (1988) and others (Broverman et al., 1972; Laws, 1979; Wilson and Boldizar, 1990) suggest that the gender socialization process provides clues to understanding the academic choices of students. They state that "the way young girls [and young boys] are socialized is crucial - that the values that surround them and the expectations of them encourage and cue them to pursue particular educational and occupational choices" (Nevitte et al., 1988:34). These choices are influenced by what society has deemed appropriate for the sexes. Traditionally, "women were thought to prefer work, such as teaching, which represented an extension of their domestic roles and involves helping, nurturing or socializing activities" (Almquist, 1974:14). Men, on the other hand, tended to dominate the business, science, and the technological spheres of the workplace. The existence of "men's work" and "women's work" emerged out of the roles that society expected of men and women. Women are capable of having children; therefore, it was assumed that a nurturing type of career was more suited to their sexual disposition. Men in contrast, are typically expected to be "independent, objective, active, competitive, logical, skilled in business, worldly, adventurous, able to make decisions easily, self-confident, always acting as a leader, and ambitious" (Broverman, Vogel, Broverman, Clarkson, and Rosenkrantz, 1972) --- in other words, to have characteristics that fit the rough-and-tumble world of business. Over time, sex-role expectations became established:

> ... men's preferences and perceptions may be influenced by the fact that their working role enables them to actualize what they assume to be their family role --- being the providers of financial comfort (Eccles, 1987) Women's preferences and perceptions, on the other hand, may reflect their multiple life demands, which include the responsibility for taking care of home and family needs in addition to their work role. (Gati et al., 1995:214).

Of interest then, is how strongly students believe in these global sex-roles. Most researchers have explored gender differences in sex-roles attitudes but they have not examined whether science students hold more conventional attitudes than nonscience students. Consequently, I have no reason to believe that science students have more traditional sex-role attitudes than social science students. I predict, then, that there will be no differences in the global sex-role attitudes of science and social science majors (Hypothesis 11).

Turning to science-specific sex-role attitudes, researchers have examined the extent to which students believe that women can combine a science career with a family (Farmer et al., 1995; Ferry, 1982; Lips, 1992; Morgan, 1992; Pathways Project, 1993; Rossi, 1965). Their findings suggest men believe that it will be difficult for women to have both (Lips, 1992; Morgan, 1992). Women, in contrast, believe that they will be able to have a career in science and a family, as the following quote illustrates; "It is still difficult, though possible to combine serious research with the woman's traditional role of wife, mother, and homemaker" (Ferry, 1982:13). The Pathways Project (1993) tapped societal attitudes about women in science by asking students whether they believed that society encouraged women to pursue science. It found that science majors were twice as likely as nonscience majors to express this belief. Based on this observation, I predict that science majors will believe more strongly that society encourages women to pursue science than social science majors (Hypothesis 12).

Intellectual Orientation

In all strands of research, the intellectual orientation of students has been shown to be of particular importance when examining differences in the academic choices of undergraduates (Brooks and Betz, 1990; Brush, 1991; Deboer, 1984,1986; Sonnert and Holton, 1996; Wheeler, 1983). Three key factors are: a preference for material with precise answers, mathematics self-efficacy, and science self-efficacy. The Pathways Project (1993) was the first study to highlight differences in the intellectual style of students and their implications for choice of undergraduate major (at least for women). It found that science majors were significantly more likely to have a preference for material with precise answers than nonscience students. Because the difference between science and social science majors appears to be subject-related rather than gender-based, this pattern should also hold for men. Therefore, I predict that science majors will have greater preference for material with precise answers than social science majors (Hypothesis 13).

Research on the impact of intellectual orientation on choice of major has also examined students' self-efficacy. Self-efficacy is the belief that one can perform a specific behaviour successfully (Thoits, 1995). Two types of self-efficacy have been shown to differ by college-major choice: science self-efficacy and mathematics self-efficacy (Deboer, 1984, 1988; Farmer et al.,1995; Lent, Lopez and Bieschke, 1991). Compared to nonscience majors, science majors exhibit high levels of science self-efficacy and mathematics self-efficacy. In the Pathways Project (1993), eighty percent of its science majors believed that their mathematical ability was above average. Only fifty percent of nonscience majors ranked their ability at the same level. Taken together these observations suggest two predictions. First, science majors will display greater science self-efficacy than social science majors (Hypothesis 14). Second, science majors will also display greater mathematics self-efficacy than social science majors (Hypothesis 15).

Encouragement to Pursue Science

All strands of research note that encouragement from others is an important influence on the academic choices of undergraduates (Chipman and Thomas, 1987; Pathways Report, 1993; Ware and Lee, 1988). Most of the research has focussed on the informal and formal encouragement that women receive when entering nontraditional fields (Ethington and Wolfe, 1988). Informal encouragement primarily comes from parents or peers, whereas formal encouragement may be offered by teachers, professors, or mentors. Researchers have found, for example, that women (pioneers) pursuing nontraditional fields of study, like science, receive more encouragement from parents, peers and academic associates (e.g., teachers, professors, counsellors) than do women pursuing traditional fields of interest (Houser and Garvey, 1985; Pathways Project, 1993). The four strands of research all recognize the importance of parents in an individual's life, but their importance is particulary stressed in the literatures that focus on women. Lewko et al. (1993) found that the parents of their science students were very supportive and encouraging. They go on to argue, however, that parents tend to support their children in whatever academic/career path their child chooses to follow. Other reseachers have found that science majors do receive more support to pursue science than nonscience majors (Pathways Report, 1993).

Peers are often very important in students lives. But little attention has been paid to the encouragement peers offer to one another and the studies that have been conducted offer mixed results. Chipman and Thomas (1987) note that some students rate encouragement from peers as unimportant. The work of Hallinan and Williams (1990), in contrast, showed that peers were influential in students' decisions about attending college and choosing majors. Houser and Garvey (1985) also note that individuals pursuing nontraditional vocations received higher levels of peer support than those following traditional vocational paths.

Unlike peers, academic associates and the encouragement they provide to students have been studied at all points on the science pipeline (Chipman and Thomas, 1987; Farmer et al.,1995; Lewko et al.,1993; Pathways Project, 1993; Ware and Lee, 1988). For example, Ware and Lee (1988) found that science teachers were able to stimulate an interest in their students. They also found differences in the amount of influence of both high school and university staff on science and nonscience students' choice of major.

Rather than highlighting the encouragement that many academic associates provide to students, some researchers have focussed on the presence of a mentor. (Primack and O'Leary, 1993; Ragins and McFarlin, 1990). Mentors are defined as "higher ranking, influential senior members of the organization who are committed to providing upward mobility and support to their protege's career" (Ragins and McFarlin, 1990:321).

Taken together, research on these sources of encouragement to pursue science suggest that science majors will have received more encouragement to pursue science than social science majors (Hypothesis 16).

CHAPTER THREE:

PREDICTING THE PROBABILITY OF MAJORING IN SCIENCE:

A REVIEW OF THE LITERATURE

Chapter Two used concepts and substantive findings from all four strands of research on academic choices to set out predictions for differences between the science and social science majors. In this chapter, I draw on the same literature to develop my models predicting the probability of majoring in science. For each of the six sets of variables that frame my models, I set out the rationale for my predictions (Model One). I also identify factors where the effects are hypothesized to differ for women and men (Model Two).

Family Background

Studies conducted in all strands of research on academic choices have established that two family background factors influence students' choice of undergraduate major: parental education and parental occupation (Nevitte et al., 1988; Ware et al.,1985). Ware et al. (1985) found that students with highly educated parents are more likely to major in science than nonscience students. They suggest that highly educated parents instill in their children the belief that academic accomplishments are important and desirable. They also note that these parents are able to afford the education programmes and tutoring that expose their children to science and help them to develop their scientific skills. And, because better educated parents tend to have more liberal ideas of appropriate sex-role behaviour, these researchers also suggest that women with highly-educated parents are less likely to be discouraged from enrolling in the "male domain" of science (Ware et al.,1985).

The academic choices literature on science students also emphasizes the importance of highly educated parents, especially for women (Bielby, 1981; Haertal, Whalberg, Junker, and Pascarella, 1981; Lewko et al., 1993; Sandberg et al., 1987; Ware and Lee, 1988; Ware et al., 1985). O'Donnell and Anderson (1978) and others report that women in various male-dominated majors tend to have better educated mothers than women who major in female-dominated subjects (Frieze et al., 1984; Houser and Garvey, 1985). The Pathways Project (1993) found that the female-science sample had very well-educated parents. Taken together, then, these strands of research suggest four predictions. First, students with more highly educated fathers are more likely to major in science (Hypothesis 17). Second, the effect of father's education will be stronger for women than for men (Hypothesis 17a). Third, students with more highly educated mothers are more likely to major in science (Hypothesis 18). Fourth, the effect of mother's education will be stronger for women than for men (Hypothesis 18a).

Turning to parents' occupation, researchers from the science strands of research have explored the effects of having a parent in a science-related occupation (Breakwell, Fife-Schaw, and Devereux, 1988; Lewko et al.,1993; Nevitte et al.,1988; Pathways Project, 1993). Breakwell et al. (1988) found that students were more likely to aspire to a technological (science-related) career when either parent was involved or had contact with technology in their work. By "demystifying" science, they increase the probability that their children will choose an undergraduate major in science. Nevitte et al.(1988) had a similar finding: father's occupation was an important predictor of his daughter's degree programme. They argue that because the female socialization process does not traditionally provide women with an idea of what the science domain entails, having a parent, usually a father, in science provides women with this information.

The impact of mother's occupation on undergraduate academic choices has received less attention. But, if participation in a science-related career leads fathers to "demystify" science for their daughters (and sons), as Nevitte et al. (1988) suggest, then this relationship should also hold for mothers' occupation. This argument is consistent with the Pathways Project's (1993) finding that science majors were twice as likely as nonscience majors to have mothers in science-related occupations. Taken together, this research on father's and mother's occupations suggests four predictions. First, students whose fathers work in science-related occupations are more likely to major in science than students whose fathers do not work in science-related occupations (Hypothesis 19). Second, the effect of having a father in science-related occupation will be stronger for women than for men (Hypothesis 19a). Third, students whose mothers work in science-related occupations are more likely to major in science than students whose mothers do not work in a science-related occupation (Hypothesis 20). Finally, the effect of having a mother in a science-related occupation will be stronger for women than for men (Hypothesis 20a).

High School Experiences

Most students who eventually major in science intend to major in science before entering university, and this intention is partly the result of high school experiences (Deboer, 1986; Ethington and Wolfe, 1988; Lips, 1992; Nevitte et al.,1988; Pathways Report,1993; Ware and Lee, 1988; Ware et al.,1985). Almost all high school students take both mathematics and science classes. How they respond to these classes often determines whether or not they choose to enrol in science at university. Therefore, preparation and performance (grades) in mathematics and science are important factors to consider when predicting which students choose a science major.

Research has shown that the number of mathematics and science courses students take in high school influences whether or not they decide to pursue science in university (Deboer, 1986; Ethington and Wolfe, 1988; Lips, 1992; Nevitte et al., 1988; The Pathways Project, 1993; Ware and Lee, 1988). Students who take more mathematics and science courses in high school rate their ability to do well higher, and students who rate their science ability higher take more science courses in university (Deboer 1986). And, as the quotation from Lovely (1987) presented earlier makes clear, students who lack preparation in mathematics and science do not view science as a viable choice of major. I predict then, that the more high school mathematics courses students take, the more likely they are to major in science (Hypothesis 21). And, I predict that the more high school science courses students take, the more likely they are to major in science (Hypothesis 22).

Turning to achievement, the Men and Women in Science strand of research has recognized that students who perform well in mathematics and science are far more likely to continue their studies in science than students who perform poorly (Deboer, 1986). In this context, performance does not refer to students' perceptions of their own ability (self-efficacy). It refers to an objective evaluation by high school teachers; that is, to the grades they received in mathematics and science courses. Research indicates that students who have high mathematics and science grades are more likely to major in science (Ethington and Wolfe, 1988; Fassinger, 1990; Meece, Parsons, Kaczala, Goff, and Futterman, 1982; Nevitte et al.,1988; The Pathways Project, 1993). Based on these findings, I predict that students with higher mathematics and science grades will be more likely to major in science (Hypothesis 23).

Student Interests

In Chapter Two I noted that level of interest in science, careers and their associated job rewards have all been studied by researchers examining academic choices of students (Almquist, 1974; Lips, 1992; Pathways Project, 1993; Ware et al., 1985; Ware and Lee, 1988). Interest in science has been established as a key determinant of majoring in science (Pathways Project, 1993; Steinkamp and Maehr, 1984; Ware et al., 1985). The Pathways Project (1993) found that "it is unlikely that many women will enter science fields if they have not shown prior interest...it appears that before young women enter college, much of the predisposition to either enter or not enter science is already determined" (113). Because this pattern also holds for men, I predict, that the more interested students are in science, the more likely they are to major in science (Hypothesis 24).

Students' occupational aspirations also influence choice of major. Students who aspire to careers in science are more likely to major in science at university than students who do not have these career aspirations (Goldman and Hewitt, 1976; Pathways Project, 1993). I predict then, that students who aspire to science-related careers are more likely to major in science than those who do not have science-related career aspirations (Hypothesis 25).

If "individuals choose occupations on the basis of internalized interests and work values" (Marini et al., 1996:51), then job rewards should also have implications for undergraduate choice of major (Almquist, 1974; Brooks and Betz, 1990; Frieze et al., 1984; Gati., et al., 1995). The stereotype of the scientist as asocial, task-oriented rather than people-oriented (Lips, 1988) and the perception that scientists work long hard hours in the lab, often in isolation (Etzkowitiz et al., 1994; Frieze et al., 1984) add to the belief that scientists do not place much emphasis on working with people. Lips (1988) observed that the desire to work with people was a significant negative predictor for majoring in science. Consequently, I predict that the less students value working with people, the more likely they are to major in science (Hypothesis 26).

Sex-Role Attitudes

Research on the factors affecting academic choice of undergraduates has established the importance of considering students' sex-role attitudes. Wilson and Boldizar (1990) argue that the cumulative effects of traditional gender socialization have led to differences in men's and women's aspirations toward quantitatively-oriented majors. This argument is consistent with Smith-Lovin's and McPherson's (1993) conclusion that socialization into traditional sex-roles locates men and women in different spheres of society -- spheres that are characterized by different types of information and expectations. They found that the conventional female sphere is rich in information on the household and children and expectations of being a mother and a wife. The conventional male sphere, on the other hand, contains information on science-related majors and careers, thus leading to the expectation that men will choose a science major (Erickson and Erickson, 1984; Zerega and Walberg, 1984). Their findings are consistent with those of Erickson and Erickson (1984). They found their female respondents had a better understanding of kitchen-related items (e.g. opening a jam jar lid by running hot water on the lid) but less understanding of mechanical-related items (e.g. the purpose of a fuse or circuit breaker).

These findings suggest that men and women may acquire different types of information that help them to make academic choices. The literature suggests, however that global sex-role attitudes has differing effects for men and women. That is, this variable has an inherent gender interaction such that holding traditional global sex-role attitudes increases the likelihood of majoring in science for men, but decreases the likelihood for women. Without taking into account this gender interaction, these effects likely cancel each other out, and consequently, I predict that global sex-role attitudes will have no impact on choice of major (Hypothesis 27). For Model Two however, I predict that the effect of global sex-role attitudes will be different for males and females, such that men with more traditional attitudes will be more likely to major in science, but women with more traditional attitudes will be less likely to pursue this undergraduate major. (Hypothesis 27a).

Turning to students beliefs about science-specific sex-role orientations, the Pathways Project (1993) showed that the belief that society encourages women to pursue science clearly differentiated science majors from nonscience majors. Although they did not explore whether this perception predicted majoring in science, I argue that this will be the case, at least for women. If students perceive that societal attitudes toward science as a male domain have changed, then science becomes a more attractive option for women and men. On these grounds, I predict first, that the more students believe that society encourages women to pursue science, the more likely they are to major in science (Hypothesis 28). Second, the effects of this belief will be stronger for women than for men (Hypothesis 28a).

Intellectual Orientation

Preference for material with precise answers, science self-efficacy, and mathematics self-efficacy have all been established as key factors predicting the academic choices of students. The Pathways Project (1993) noted that students choose majors that reflect their intellectual styles. It found that "non-science majors were three times as likely as science majors to prefer subjects where the material has multiple interpretations as opposed to precise answers" (1993:51). Because this pattern should also hold for men, I predict that students who prefer material with precise answers are more likely to major in science than students who prefer material with multiple interpretations (Hypothesis 29).

Students' perceptions about their abilities to perform in relevant subject areas also predict choice of undergraduate major. Because perceptions may be more consequential than actual ability (Pajares and Miller, 1995; Wheeler, 1983), students who believe that they are capable of doing science are more likely to pursue a science major in university.

According to Betz and Hackett (1983), mathematics self-efficacy is associated with choice of, and persistence in, science- and math-related college majors. They suggest that the more mathematics self-efficacy students have the more likely they are to pursue a science major.

The Men and Women in Science strand of research has emphasized the gender differences in levels of science and mathematics self-efficacy (Betz and Hackett, 1983; Farmer, et al., 1995; Parjares et al., 1995; Frieze et al., 1982; Ware and Lee, 1988). Researchers have found that women tend to rate their science ability lower than men (Deboer, 1986; Lent et al., 1991). Studies have shown that,

> substantially more men than women reported that they considered their scientific ability to be above average. More women considered their ability to be average. And when asked whether they should have handled their career [undergraduate major] obstacles in a different way, many more women than men thought they should have had more confidence...(Sonnert and Holton, 1996:67)

Much of this research has focussed on women's tendency toward mathematics anxiety and suggest that this anxiety contributes to women's lower levels of mathematics self-efficacy (Brush, 1991; Felson and Trudeau, 1991; Sherman, 1982). Following these arguments, I predict that students with more science self-efficacy will be more likely to major in science (Hypothesis 30). Second, the effect of science self-efficacy will be stronger for women than for men (Hypothesis 30a). Third, students with more mathematics self-efficacy are more likely to major in science (Hypothesis 31). Fourth, the effect of mathematics self-efficacy will be stronger for women than for men (Hypothesis 31a).

Encouragement to Pursue Science

Studies from all strands of research have consistently shown that encouragement from parents, peers, (informal sources) and academic associates like teachers, professors, and mentors (formal sources) affects whether students decide to major in science. This literature has focussed almost exclusively on the importance of encouragement for women who choose nontraditional majors and careers, such as science (Ethington and Wolfe, 1988; Frieze et al., 1982; Pathways Report, 1993; Ware et al., 1985). I argue that the effects of encouragement should also hold for men.

Encouragement from parents and peers ranges from simply listening to the concerns of the student to actively promoting science as a desirable academic choice. It usually does not involve espousing the "greatness of science," nor actively pushing the student to attempt to make scientific discoveries of science. To explore the effects of encouragement from parents, some researchers have asked students how critical this encouragement was in their decision to pursue science. The Pathways Report (1993) found that most science majors reported receiving encouragement from their parents. Houser and Garvey (1985) concluded that the factor that most significantly differentiated women in traditional fields from their nontraditional counterparts was the amount of support and encouragement they received from parents. Ferry and Moore's (1982) collection of "True

Confessions of Women in Science" also notes that father's encouragement was a significant reason for entering the scientific field.

As mentioned in Chapter Two, peer influences on the decision to pursue science in university are less well studied than other sources of encouragement (Chipman and Thomas, 1987; O'Donnell and Anderson, 1978). Chipman and Thomas (1987) found that some students rated peer influence as unimportant, but even these students reported that their friends had the same attitudes and plans as them. If these attitudes and plans included attitudes toward science and science-related career aspirations, then peers may affect students decision to major in science. Hallinan and Williams' (1990) finding that peers tend to have similar backgrounds and interests and that these similarities strongly influence the academic choices of students supports this argument. Houser and Garvey (1985) conclude that the support and encouragement students received from peers differentiated women entering nontraditional fields like science from those entering traditional fields.

Turning to encouragement to pursue science from formal sources, research findings suggest that high school teachers are in a position to provide information about their own university science education, the difficulty of university science courses, and the workload and grading procedures associated with these courses (Hallinan and Williams, 1990).

They can also encourage students who show an interest and aptitude for science, often recommending courses that will better prepare them for an undergraduate science major. Most studies have focussed on the high school teachers because students tend to have more contact with them than with university professors (Ware and Lee, 1988). The Pathways Project (1993) found that many of their undergraduates had limited contact with faculty. They note, however, that as students progress through university the probability of faculty interaction increases.

One formal source of encouragement that has received considerable attention in the literature on science as an academic choice, is mentors. Researchers from the Women in Science strand of research argue that the guidance provided by a mentor affects choice of major and continued participation in that field (Ware and Lee, 1988). Feminist scholars, in particular, have stressed the need for mentors for women in science (Primack and O'Leary, 1993; Rosser, 1993). They argue that mentoring would increase the number of women choosing science majors and careers, by providing direction and support to up-and-coming female scientists (Etzkowitz et al., 1994; Nelson and Quick, 1985). At the heart of most of this research, then, is the assumption that women need support from multiple sources to help them combat the "chilly climate" of science.

Mentors can be high school teachers who continue to play an influential role in the students' lives once they have left high school. They can be university professors who take an interest in the student, show them the ropes, and provide emotional support and encouragement to pursue science. As one student commented, her mentor showed her "how to dress, how to act at conferences, and what to do when someone is curt to you" (Etzkowitz et al., 1994:52). Mentoring influences not only the choices of undergraduate major but also continued participation in that major (Ware and Lee, 1988).

Researchers studying gender differences in academic choices suggest that having a mentor is more important for women than for men because women in science face numerous barriers (Frieze at al., 1984; Ware et al., 1988). Receiving guidance and support from individuals involved in science helps students cope successfully with this unwelcoming environment, especially if their mentor is also a woman. Primack and O'Leary's (1993) study of ecology students identified the lack of available female mentors as a significant factor in students' dissatisfaction with the academic environment. Others have found that,

> female protegees who have female mentors were more likely to agree with the idea that their mentors served a role modelling function... by observing female mentors, female protegees may vicariously learn strategies for coping with work-family conflict and gender related barriers to advancement (Nelson and Quick, 1985 as cited in Ragins and McFarlin, 1990:34).

Following these studies of the effects of encouragement, I predict that the more encouragement students receive to pursue science the more likely they are to major in science (Hypothesis 32). And, the effect of encouragement to pursue science will be stronger for women than for men (Hypothesis 32a).

CHAPTER FOUR:
DATA AND METHODS

The purpose of this chapter is to describe the data and procedures that are used to examine the differences between science and social science majors and to predict the choice of a science major. It includes a discussion of the sample, the measurement of the variables, and the data analytic techniques I employed in this study.

Sample

The data for this study are from an 1994 exploratory study of the academic choices of undergraduates at a commuter university in a large, metropolitan city in Western Canada. Of these approximately 18,000 full-time students, 1,646 were in the Faculty of Science and 2,585 were in the Faculty of Social Science. In April, I sent a survey to 1,000 full-time students in the Faculties of Science and Social Science. Each respondent received a copy of the questionnaire with a cover letter, consent form, prepaid return envelope, and a set of forms used to collect network data. Because I wanted to compare science and social science majors, the sample was stratified by faculty such that half of the surveys were sent to science majors and half to social science majors. To select respondents, I began by using proportionate sampling by department with a random start. Where department subsamples were less than 50 students, I oversampled to 50 (e.g., Chemistry, Mathematics, Anthropology, Archaeology, Linguistics) or sent surveys to all majors (Geology, Physics). Numbers permitting, I oversampled the under-represented genders for male-dominated departments and female-dominated departments to 15 students per department. A second mailing to 200 students was made later in April. I conducted one telephone follow-up for each mailing.

A total of 281 surveys were returned. My response rate of 23.4% is at the low end of the range of returns (24-90%) provided by Miller (1991) for questionnaires mailed to American high school and college graduates. It is consistent however, with student participation rates in elections at this particular university (e.g., 19.5%) and with consistently low turn-out rates at commuter universities in general (Grayson, 1994). Both the timing and complexity of the survey also likely contributed to the low response rate. Funding constraints forced me to conduct the survey during the last month of the winter term when demands on the students' time are heaviest. The survey was long (24 pages plus 9 network forms) and, because it included a network component, it elicited information not only about respondents but also about members of their personal networks. Survey network data are not usually collected by mail questionnaires, which may also account for the lower than average response rate. While respondents did not have difficulty completing the network forms, some reported that this component of the survey was very time intensive. On average, it took respondents 1.5 hours to complete the survey.

Despite the response rate, the sociodemographic characteristics of the sample were quite similar to those of the population of science and social science majors. Table 1 shows that the only significant difference between the sample and the population is in the gender distribution, which was to be expected given the sampling strategy used.

Table 1: Comparison of Population and Sample Data

	Population Data (N=4003)	Sample Data (N=281)
Faculty	40% Science 60% Social Science	43% Science 57% Social Science
Gender	48% Male 52% Female	34% Male * 66% Female *
Age	85% under 25	79% under 25
Home Address	80% Local	93% Local

* p<0.10 for two tailed test.

I did not include all 281 cases in my statistical analyses because I used listwise deletion. Listwise deletion is a statistical procedure that is adopted to deal with missing values (Norusis, 1990:190). Following it meant that I eliminated from my analyses cases which had missing values on any variable in my models. My sample size throughout the statistical analyses is 248.

Controls are often incorporated in statistical analyses to ensure that relevant theoretical variables have not been excluded. Control variables are variables that the researcher believes may have an effect on the dependent variable and therefore should be held constant when evaluating the model. I initially selected age and marital status as control variables. But after examining both the frequencies and descriptive data, I discovered that there was very little variation in either variable; 87% of the sample was between 19 and 27 years old (mean=23.90, S.D=4.37). Also, 81% of the sample were single (mean=.81, S.D.=0.39). What these findings suggest is that by virtue of the sample these variables are being held constant and, therefore, there is no need to incorporate them into the models. In addition, because I have specified both father's and mother's educational attainment as key variables in the model, I am essentially controlling for socioeconomic status. Consequently, these three traditional control variables are not included in the analyses that follow.

MEASUREMENT

Before describing the measures for the variables used in my analysis, I will address three measurement concerns: validity, reliability and multicollinearity. One question often raised in research is "how do social scientists determine the extent to which a particular indicator or set of indicators represent a theoretical concept?" (Carmines and Zeller, 1982:11). Tests of validity are used to establish whether each measure represents what it was intended to reflect. Validity is defined as the extent to which any measuring instrument measures what it is intended to measure. I use both face validity and construct validity to demonstrate the validity of my measures. Face validity is simply whether "something appears to be true 'on the face of it'" (Goldenberg, 1992:102). In a sense, then, face validity is assessed by commonsense; if the measure seems plausible then face validity is present. Consider, for example the measure I used to tap the construct of career aspirations. It asks "what occupation do you hope to pursue". This question appears to be a logical and straight-forward way of obtaining information on a student's occupational aspirations. The descriptions of the specific measures that follow suggest that all have face validity.

Construct validity is a more sophisticated method for demonstrating validity. It "is concerned with the extent to which a particular measure relates to other measures consistent with theoretically derived hypotheses concerning the concepts (or constructs) that are being measured" (Carmines and Zeller, 1982:23). As Babbie (1989) points out, when developing measures, certain expectations are arrived at and these are the expectations that are tested when demonstrating construct validity. Carmines and Zeller (1982) suggest three steps are involved in demonstrating construct validity. First, "the theoretical relationship between the concepts must be specified" (23). Second, "the empirical relationship between the measures of the concepts must be examined" (23). The third step, involves "the interpretation of the empirical evidence" (23). To meet the second and third requirements, I examined the underlined zero-order correlations in the correlation matrix presented in Table 2. I selected these correlations because these bivariate relationships have been specified theoretically in the literature on academic choices. In all cases the relationships are present and in the hypothesized direction.

Reliability refers to "the extent to which an experiment, test, or any measuring procedure yields the same results on a repeated basis" (Carmines and Zeller, 1982; 11). Essentially reliability relates to consistency; a measure has to be reliable for it to be useful (Norusis, 1990:463). The most commonly used test of reliability is the coefficient called "Cronbach's Alpha". This coefficient is based on internal consistency of items and ranges from 0.00 to 1.00, with a large number indicating a reliable scale (Norusis, 1990:467). The alpha levels reported for the multiple-item measures indicate acceptable levels of internal consistency.

Table 2: Correlation Matrix of the Variables in the Proposed Models for Predicting Majoring in Science (N = 248)

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
1. Major (Science)	1.00																	
2. Father Education	.12	1.00																
3. Mother Education	.04	.50*	1.00															
4. Father in Science	.04	.32*	.08	1.00														
5. Mother in Science	-.02	.01	.19*	.01	1.00													
6. Math Preparation	.38*	.14*	.09	.05	.10*	1.00												
7. Science Preparation	.32*	.15*	.04	.03	.11*	.36*	1.00											
8. Math/Science Grades	.47*	.18*	.10	.05	.04	.46*	.57*	1.00										
9. Science Interest	.52*	.10	.03	.05	.01	.24*	.27*	.38*	1.00									
10. Career Aspirations	.56*	.04	.06	-.02	-.04	.31*	.22*	.34*	.40 *	1.00								
11. Working with People	-.16*	.11*	.04	.04	-.05	-.02	-.05	-.07	-.15*	-.11*	1.00							
12. Global	.09	-.08	-.14	-.01	.01	.01	.08	.03	-.03	.02	-.10*	1.00						
13. Science-Specific	.16*	.10	.04	.12*	.09	.10*	.17	.09	.07	.15*	-.02	.21*	1.00					
14. Precise Answers	.49*	.03	-.08	.03	-.03	.18*	.16*	.21*	.34*	.40*	.19*	.08	.10*	1.00				
15. Math Self-Efficacy	.34*	.02	.06	-.03	.03	.35*	.16*	.47*	.31*	.19*	-.07	.05	.08	.20*	1.00			
16. Science Self-Efficacy	.45*	.06	.09	.09	.00	.23*	.15*	.42*	.54*	.32*	-.14*	.03	-.00	.20*	.58*	1.00		
17. Encouragement	.36*	.25*	.22	.11*	.04	.22*	.24*	.30*	.32*	.23*	.00	-.14*	.06	.20*	.16*	.21*	1.00	
18. Gender (Male)	.17*	-.02	-.01	.01	.08	.20*	.13*	.14*	.08	-.04	-.15*	.28*	.09	-.05	.21*	.19*	-.06	1.00

* Significant at the 0.10 level, one-tailed test.

I used a two-step strategy to demonstrate single-item reliability. First, where possible I employed single-item measures that have been used in previous research. Second, I examined the correlation matrix (Table 2) to see if these items behaved in the same way in my study as they did in previous studies. Table 2 suggests that the correlations between the dependent variables and the single item measures are consistent with those reported elsewhere. For example, to tap whether students had a preference for material with precise answers I used the Pathways Project (1993) measure. The Pathways Project (1993) found that there was a moderately high positive correlation between majoring in science and a preference for material with precise answers, I also found a moderately high correlation between these variables (r=0.49).

Multicollinearity refers to high intercorrelations among independent variables, which, when present, can affect tests of statistical significance (Pedhauzer, 1982:235). Elifson, Runyon, and Haber (1990) suggest that previous studies can be used as guidelines in interpreting the correlations between variables. But the general rule of thumb for a high correlation between the two independent variables is 0.80 or higher (Asher, 1983; Berry and Feldman, 1985). To determine if collinearity problems exist, I examined the zero-order correlation matrix. Because none of the correlations between my independent variables approach

0.80, multicollinearity does not appear to be a problem in this study.

MEASURES

I use both single and multiple-item measures in this study. Many of these are Likert items, where the response options are: strongly agree (5) agree (4), neither agree nor disagree (3), disagree (2), or strongly disagree (1). The Likert format lends itself to scale construction because "identical response categories are used for several items intended to measure a given variable" (Babbie, 1989:405). Scales are used when a variable is not accurately represented by a single empirical measure. Consequently, several items are used to tap into the different dimensions of the variable of interest. Of interest in this study was global sex-role attitudes (Mason, Czajka, and Arber, 1976) which will be discussed in greater detail later in this chapter. I begin this section with a discussion of the measurement of the dependent variable. Following this, the measures of the independent variables are presented.

Table 3 provides a summary of the descriptive data for all variables used in the analysis.

Table 3: Descriptive Data for the Proposed Models (N=248)

	#Items	Mean	S.D	Range
Major(Science)	1	0.43	0.50	0-1
Family Background				
Father's Education	1	4.27	2.18	0-8
Mother's Education	1	3.75	1.92	1-5
Father in Science	1	0.21	0.41	0-1
Mother in Science	1	0.16	0.37	0-1
High School Experiences				
Math Preparation	1	0.47	0.50	0-1
Science Preparation	1	6.92	2.27	1-9
Math/Science Grade	1	3.45	1.46	1-5
Student Interests				
Interest in Science	1	3.74	1.08	1-5
Career Aspirations	1	0.43	0.50	0-1
Working with People	3	1.58	1.12	1-3
Sex-Role Attitudes				
Global	3	2.26	0.87	1-5
Science-Specific	1	2.45	0.95	1-5
Intellectual Orientation				
Precise Answers	1	1.05	0.98	0-1
Science Self-Efficacy	1	3.56	0.85	1-5
Math Self-Efficacy	1	3.29	1.00	1-5
Encouragement	5	2.01	1.49	1-5
Gender (Male)	1	0.34	0.48	0-1

Dependent Variable

Major (Science) - The dependent variable, Major (Science), was measured by a single item that was dummy coded 0 for Social Science and 1 for Science. This coding procedure was adopted because my model is predicting the likelihood of a student declaring his or her major to be science.

Independent Variables

Gender (Male) - Respondents indicated whether they were male (coded 1) or female (coded 0).

Father's Education - Respondents were asked to indicate the highest level of education completed by their father. The response categories were: 1-12 years (coded 1), high school (coded 2), some college (coded 3), technical/ college diploma (coded 4), some university (coded 5), Bachelors Degree (coded 6), Masters Degree (coded 7), Ph.D. (coded 8). When information on father's educational attainment was unavailable, but the information on mother's educational attainment was available, I was able to estimate a score for the father's educational attainment from the data. To arrive at this estimated score, I calculated the mean difference between father's education and mother's education for respondents who had complete data for both parents. This yielded a mean difference score of 0.405, which suggests that, on average, father's educational level is 0.405 higher than that of his wife. I then estimated father's education for those missing data by adding the mean difference score to his wife's (mother's) educational attainment score.

Mother's Education - Respondents were asked to indicate the highest level of education completed by their mothers. The response categories were: 1-12 years (coded 1), high school (coded 2), some college (coded 3), technical/college diploma (coded 4), some university (coded 5), Bachelors Degree (coded 6), Masters Degree (coded 7), Ph.D. (coded 8). When data were missing on the mother's educational attainment, I estimated mother's educational attainment by subtracting 0.405 from the data available for father's educational attainment.

Father in Science-Related Occupation - Respondents were asked to indicate their father's occupation. Those responses were then categorized according to the classification scheme developed by Lewko et al. (1993). This scheme consisted of three categories: Nonquantitative Science (occupations in medicine, health and the life sciences), Quantitative Science (occupations in the natural sciences, engineering and mathematics), and Nonscience (occupations in education, humanities, managerial, administrative, clerical, sales and service, manual labour and occupations in the social sciences) (Lewko et al.,1993:71). Because my focus is science-related occupation versus nonscience occupations, I collapsed the Nonquantitative and Quantitative categories into one category of science-related occupations. Father's occupation was coded as science related (1) and nonscience related (0).

Mother in Science-Related Occupation - Respondents were asked to indicate their mother's occupation. I used the procedure described for father's education to code mother's occupation as science related (coded 1) and nonscience related (coded 0).

Mathematics Preparation - Respondents were provided with a list of all available high school mathematics courses and asked to provide the grade they received in each course. The presence or absence of a grade indicated whether or not a course had been taken. Because Math 30 (and therefore its prerequisites of Math 10 and Math 20) are mandatory for matriculation, my measure of math preparation is whether (coded 1) or not (coded 0) Math 31 was completed. Math 31 is an advanced mathematics course and can only be taken by students who have shown a degree of competence in previous mathematics courses.

Science Preparation - Respondents were provided with a list of all available high school courses in Chemistry, Biology, and Physics and asked for their grade in each course. The presence or absence of a grade indicated whether (coded 1) or not (coded 0) each course had been completed. The measure of science preparation is the number of chemistry, biology, and physics courses that were completed. The measure ranges from 1 (low preparation) to 9 (high preparation).

Mathematics and Science Grades - Mathematics and science grade was generated from respondent's self-reports of the grades they received for each high school math and science course they had completed. The response options were as follows as 80-100%, 70-79%, 60-69%, 50-59%, below 50%. These were then coded as 5, 4, 3, 2, and 1 respectively. These values (1 to 5) were then averaged across the number of courses taken, to provide a single score. A high score

(5) indicates a high grade in science and mathematics courses.

Interest in Science - Respondents were asked to rate their degree of interest in science by indicating whether they consider their level of interest to be: "in the top 10% of people" (coded 5), "above average" (coded 4), "average" (coded 3), "below average" (coded 2), "in the bottom 10%" (coded 1). A high score (5) indicates a high degree of interest in science.

Career Aspirations (Science) - Following Nevitte et al.(1988), respondents were asked "what occupation do you hope to pursue?". I used the procedure described above for father's occupation to code their responses as science-related (coded 1) or nonscience-related (coded 0).

Working with People - Following Lips (1992), I used a checklist to elicit information about the work values respondent's considered most important in choosing a career. Three items tapped the importance of working with people: opportunities to be helpful to others, a chance to make an important contribution to society, and working with people rather than things. The scores from these items were coded as important (1) and not important (0) and then summed. A high score (3) indicates that the respondent values working with people.

Global Sex-Role Attitudes - A three-item scale, based on the scale developed by Mason, Czajka, and Arber (1976), was used to assess the degree to which respondents adhered to traditional sex-role attitudes. A factor analysis procedure was used to identify those items that tapped into global sex-role attitudes. The factor analysis procedure rotated the items with one another until it was able to group those items that all tapped into a similar construct, i.e., traditional sex-role attitudes. The items selected were: "A working mother can establish just as warm and secure a relationship with her children as a mother who does not work"; "It is much better for everyone involved if the man is the achiever outside the home and the woman takes care of the home and family"; "A preschool child is likely to suffer if his mother works". Once these items were identified, tests of internal consistency were conducted which provided an indication of the inter-item reliability. The reliability score is 0.71 which means that the multiple items selected work well together in measuring traditional sex-role attitudes. A scale was then created by averaging the scores the respondents received on three Likert statements. The mean score was computed and a single score was obtained. A high score (5) represented attitudes reflecting high agreement with traditional global sex-roles.

Science-Specific Sex-Role Attitudes - Respondents were asked to indicate the extent to which they agreed with the following statement: "Society encourages women to pursue science". Scores to this Likert item were coded so that a high score (5) represents a high level of agreement with the statement.

Precise Answers- This single-item measure asked respondents to respond to the following: "I prefer subjects where the material has: precise answers (coded 2) or multiple interpretations (coded 0). Because some individuals indicated a preference for both types of material, I created an intermediate category of "both types of material" (coded 1).

Science Self-Efficacy - Respondents were asked to rate their science ability as "in the top 10% of people" (coded 5), "above average" (coded 4), "average" (coded 3), "below average" (coded 2), and "in the bottom 10%" (coded 1). The responses were coded so that a high score (5) indicates a high level of science self-efficacy.

Math Self-Efficacy - Math self-efficacy was measured from self-reports of respondents' mathematics ability as "in the top 10% of people" (code 5), "above average" (coded 4), "average" (coded 3), "below average" (coded 2), and "in the bottom 10%" (coded 1). The responses were coded so that a high score (5) indicates a high level of math self-efficacy.

Encouragement to Pursue Science - Respondents were asked whether their: (a) fathers, (b) mothers, (c) peers, (d) high school teachers, counsellors, university professors, graduate teaching assistants, and (e) mentors had encouraged them to pursue science, discouraged them from pursuing science or were indifferent. The responses to each question were coded with "encouraged" (coded 1) and "indifferent" and "discouraged" (coded 0). I then added across the five sources to create a single score that ranges from 1 to 5. A high score (5) indicates a high level of encouragement to pursue science.

DATA ANALYTIC TECHNIQUES

In this study, I use two data analytic techniques to conduct three statistical analyses. First, I employ differences in means tests to see if there are statistically significant differences between science and social science majors. Second, I conduct a logistic regression analysis to predict the probability of majoring in science. Third, I add nine gender-interaction terms to the model predicting the probability of majoring in science and re-estimate it using logistic regression to determine whether the effects of the variables are dependent upon the gender of the respondent. Two models are used in this study: Model One corresponds to the first logistic regression (without gender interactions) and Model Two corresponds to the second logistic regression (with gender interactions). Each of these techniques are discussed in greater detail below.

The first step in the analysis involves calculating the differences in means, which entails dividing the sample into two groups that differ on the dependent variable (science major versus social science major) (Loether and McTavish, 1980). Next, the mean levels on the variable of interest (e.g., father's education) are compared to see if there is a statistically significant difference across the two groups. If the quantitative differences found between science and social science majors are statistically significant, then my results are not derived by chance. To determine whether this is the case, a significance level is set and, if that level is exceeded, then the results are said to be the result of nonchance factors (Elifson et al., 1990:338). Achieving statistically significant results demonstrates that the results were not achieved by chance, and that the sample results do not differ significantly from the population characteristics. I use one-tailed tests of significance because I predicted *a priori* the expected direction of the difference between the two groups. In many studies the level of significance is set as the 0.05 level, but, because my sample is relatively small, the 0.10 level of significance is more appropriate.

The second step in the analysis consists of predicting the probability of majoring in science (Model One). Because my dependent variable is categorical there are only two possible values: a science major or not. Therefore, ordinary least squares (OLS) regression is not appropriate and cannot be used because it requires that the dependent variable be, at minimum, a continuous, interval measure (Aldrich and Nelson, 1986). Logistic regression is appropriate when the dependent variables is dichotomous. When using logistic regression the results and interpretations differ slightly from OLS regression. Logistic regression can be summarized as follows:

> a global test for the significance of a given predictor controlling for all other predictors in the model, as well as a test for the significance of a set of predictors, controlling for other

> effects. Moreover, the impact of a given predictor in the dependent variables, adjusted for other effects in the model, is nicely summarized by parameters that translate into odds ratios (Demaris, 1992:1).

The logistic coefficients are analogous to the OLS coefficients, but as Kay and Hagan (1994) point out, they are more cumbersome to interpret. "Logit coefficients represent the log odds of an outcome variable associated with a unit change in an independent variable" (Kay and Hagan, 1994:442). Essentially, logistic regression is determining the probability of an event occurring, e.g., majoring in science. Like OLS, logistic regression yields an R^2. This "Pseudo R^2" is a rough approximation for assessing the predictive power of the model. That is, the Pseudo R^2 assesses the predictive efficacy of the model.

Logistic regression also provides a probability value that can be transformed into a percentage by using the following formula: Exp (B) - 1.00 x 100. The interpretation of the probability estimate (percentage score) is akin to interpreting percentage odds.

The third step in the statistical analysis involves evaluating the statistical significance of the nine hypothesized gender interactions in effects (Model Two). Few studies have statistically assessed gender differences in effects for models incorporating both science and social science students. Gender differences in effects, or interaction effects, indicate whether the effect that an independent variable has on the dependent variable depends upon the gender of the respondent. Nine of my hypotheses predict gender interactions: Hypotheses 17a, 18a, 19a, 20a, 27a, 28a, 30a, 31a, and 32a.

To test for these gender interactions, I began by creating multiplicative interaction terms for all the relevant variables (e.g., gender * sex-role attitudes). Then, I re-estimated the model using logistic regression. First I compared the Pseudo R^2s for Model One (without gender interactions) and Model Two (with gender interactions). If the results indicate that the inclusion of the nine gender interactions produces a statistically significant improvement in the Pseudo R^2s, then I can conclude that Model Two with gender interactions provides a better fit to the data and therefore that the impact of certain variables depends upon the gender of the individual. Second, I identified the interaction terms that were statistically significant at the 0.10 level. This allows me to determine whether any of the specific gender interaction effects are important in predicting students' major.

CHAPTER FIVE:

RESULTS

This chapter presents the results of the statistical analyses. First, I present the findings for the mean differences tests between science and social science majors. Next, I describe the results of the first logistic regression analysis predicting the probability of majoring in science (Model One). Lastly, I discuss the results of the gender interaction tests (Model Two).

COMPARISONS OF SCIENCE AND SOCIAL SCIENCE MAJORS

I used the difference in means tests to evaluate whether there are statistically significant differences between the six sets of variables across the science and social science majors. Taken together, these tests allowed me to explore whether science and social science majors differ in the factors that are hypothesized to be associated with majoring in science. Both statistically significant and nonsignificant results are presented and discussed below. The rationale for reporting all of the results is that much of the research, and in particular that on the Women in Science and Women's Academic/Career Choices, has focussed on women in science. Few studies have evaluated whether these findings actually differentiate between science majors, both male and female, and nonscience majors. Through the use of the difference in means tests, I was able to evaluate systematically the differences between science and social science majors, for a sample that includes both male and female students. Table 4 summarizes the hypothesized differences between science and social science majors that were discussed in Chapter Two. Table 5 presents the results of the difference in means tests that I used to test these hypotheses.

Table 4: Summary of Predictions for Comparisons Between Science and Social Science Majors *

	Prediction	
	Science	Social Science
Family Background		
Father's Education (H.1)	Same	Same
Mother's Education (H.2)	Same	Same
Father in Science (H.3)	More Likely	Less Likely
Mother in Science (H.4)	More Likely	Less Likely
High School Experiences		
Math Preparation (H.5)	Higher	Lower
Science Preparation (H.6)	Higher	Lower
Math/Science Grade (H.7)	Higher	Lower
Student Interests		
Interest in Science (H.8)	Higher	Lower
Career Aspirations (H.9)	Higher	Lower
Working with People (H.10)	Lower	Higher
Sex-Role Attitudes		
Global (H.11)	Same	Same
Science Specific (H.12)	Higher	Lower
Intellectual Orientation		
Precise Answers (H.13)	Higher	Lower
Science Self-Efficacy(H14)	Higher	Lower
Math Self-Efficacy (H.15)	Higher	Lower
Encouragement (H.16)	Higher	Lower

* These hypotheses correspond to those discussed in Chapter Two.

Table 5: Summary of Mean Differences for Science Majors (N=115) and Social Science (N=153) Majors [a]

	Science Mean	Science S.D.	Social Science Mean	Social Science S.D.
Family Background				
Father's Education (H.1)	4.57	2.11	4.04*	2.09
Mother's Education (H.2)	3.83	2.00	3.68	1.86
Father in Science (H.3)	0.22	0.42	0.19	0.40
Mother in Science (H.4)	0.15	0.36	0.17	0.38
High School Experiences				
Math Preparation (H.5)	0.69	0.46	0.31***	0.46
Science Preparation (H.6)	7.75	1.95	6.28***	2.30
Math/Science Grade (H.7)	4.22	1.19	2.85***	1.36
Student Interests				
Interest in Science (H.8)	4.38	0.66	3.24***	1.07
Career Aspirations (H.9)	0.74	0.44	0.18***	0.39
Working with People (H.10)	1.37	1.06	1.74**	1.13
Sex-Role Attitudes				
Global (H.11)	2.35	0.86	2.19	0.87
Science Specific (H.12)	2.62	1.03	2.32**	0.88
Intellectual Orientation				
Precise Answers (H.13)	1.59	0.79	0.63***	0.90
Science Self-Efficacy (H.14)	4.01	0.68	3.21***	0.79
Math Self-Efficacy (H.15)	3.68	0.91	2.99***	0.96
Encouragement (H.16)	2.62	1.41	1.55***	1.38

[a] The tests of significance indicate whether the results of the t-tests for the differences in means for the two groups (science and social science) are statistically significant.
* $p<.10$; ** $p<.05$; *** $p<.01$ for one tailed-tests.

Family Background

The difference in means tests of Hypotheses 1 and 2 were used to answer the question: Do differences exist in father's (Hypothesis 1) and mother's (Hypothesis 2) educational attainment across science and social science majors? My reading of the literature suggested that the answer would be no for both fathers and mothers. But, as Table 5 shows, there is a statistically significant difference in the levels of educational attainment for fathers of science majors (mean=4.57) and social science majors (mean=4.04). Science students' fathers have higher levels of education than the fathers of the social science students. Because there is no statistically significant difference in mothers' educational attainment between science (mean=3.83) and social science majors (mean=3.68), Hypotheses 2 was supported.

This was not the case for my hypotheses about parents' occupation. I predicted that science majors were more likely to have fathers (Hypothesis 3) and mothers (hypothesis 4) in science-related occupations. Only 22% of science majors have fathers in scientific occupations compared to 19% of the social science students, and this difference is not statistically significant. Similarly, Hypothesis 4 is not supported because only 15% of the science majors, compared to 17% of the social science students, have mothers employed in science-related occupations.

High School Experiences

My hypotheses about high school experiences explored whether differences existed in the degree of preparation and achievement in mathematics and science courses between science and social science majors. As predicted (Hypothesis 5), science majors (mean=0.69) have significantly more preparation in mathematics than social science majors (mean=0.31). Where 69% of science majors completed an advanced mathematics course, only 31% of the social science majors did. Hypothesis 6 is also supported because science majors (mean=7.75) have completed significantly more high school science courses than social science majors (mean=6.28).

Following research on achievement, I also predicted that science majors would have higher grades in mathematics and science courses (Hypothesis 7) than social science majors. Table 5 shows that science majors (mean=4.22) achieved higher grades in their high school mathematics and science courses than social science majors (mean=2.85).

Student Interests

Moving from high school experiences to current interests, I predicted that science majors would be more interested in science than social science majors (Hypothesis 8). The results presented in Table 5 are consistent with this prediction. Science majors (mean=4.38) are more interested in science than social science majors (mean=3.24) and this difference is statistically significant.

Turning to their career aspirations, I hypothesized that science students would be more interested in a science-related career than social science majors (Hypothesis 9) and this prediction was supported. The majority of science majors (74%) aspire to a science-related occupation. This is not the case for social science majors (18%).

I also predicted that science majors would attach less importance to working with people than social science majors (Hypothesis 10). The results for working with people in Table 5 support this prediction. The social science majors mean is 1.74; the corresponding value for science majors is 1.37.

<u>Sex-Role Attitudes</u>

The results presented in Table 5 indicate that, as predicted, science-specific sex-role attitudes (Hypothesis 12) differentiate science majors from social science majors, while the global sex-role attitudes (Hypothesis 11) do not. Science majors (mean=2.35) do not express more traditional global sex-role attitudes than social science majors (mean=2.19). This is not the case for science-specific sex-role attitudes. As predicted science majors (mean=2.62) show significantly more agreement with the statement that "society encourages women to pursue science" than social science majors (mean=2.32).

Intellectual Orientation

One of the most important conclusions of the Pathways Project (1993) was that science and nonscience majors have different intellectual styles. Similarly, I found that science majors express greater preference for material with precise answers (mean=1.59) than social science majors (mean=0.63) (Hypothesis 13). I also found support for the other intellectual orientation hypotheses. Table 5 shows that there are statistically significant differences in the levels of science self-efficacy (Hypothesis 14) and mathematics self-efficacy (Hypothesis 15). Science majors (mean=4.02) have more science self-efficacy than social science majors (mean=3.21) and more mathematics self-efficacy (mean=3.68) than social science majors(mean=2.99).

Encouragement To Pursue Science

My last hypothesis (16) explores differences in encouragement. I found that science students (mean=2.62) received more encouragement to pursue their major than social science students (mean=1.55) -- exactly what Hypothesis 16 predicts.

In sum, the mean differences results presented in Table 5 support thirteen of the sixteen hypotheses summarized in Table 4 and generated in Chapter Two. The Family Background factors show only one significant difference between the two majors, involving fathers' educational attainment which was not predicted. Significant differences exist in the High School Experiences of these two groups. Specifically, science majors had higher levels of preparation in science and mathematics and had higher grades in both. This suggests that science majors are better prepared to pursue a science degree in university. As predicted, science majors had more interest in science and science-related careers than social science majors, and less interest in working with people. The intellectual orientation of students also differentiated science majors from social science majors, with science majors exhibiting greater preference for precise answers and higher levels of math and science self-efficacy. And finally, science majors reported that they received more encouragement to pursue science than social science majors.

MODEL ONE PREDICTING THE PROBABILITY OF MAJORING IN SCIENCE

Turning to the results for the logistic regression analyses, I begin with Model One (no gender interactions). Table 6 summarizes its predictions and the logistic regression findings predicting the probability of majoring in science are presented in Table 7. The corresponding probability estimates (percentage odds) for each independent variable are presented in Table 8. This is followed by a discussion of Model Two (gender interactions). Table 9 summarizes the gender interaction hypotheses set out in Chapter Three and the logistic regression findings are shown in Table 10.

Model One includes seventeen variables, twelve of which are statistically significant in predicting the probability of majoring in science. The Pseudo-R^2 of 0.59 means that the model's predictive power is approximately 60%. Model One (without gender interactions) therefore, does a reasonable job of predicting the probability of a student majoring in science. A discussion of the findings for each set of factors is presented below.

Family Background

The results presented in Table 7 indicate that only two of the four Family Background variables affect the probability in majoring in science. Hypothesis 17 and 18 are not supported. For my respondents, parents' educational attainment does not influence their decision to pursue a science major. Whether or not their parents are in science-related careers does have a significant effect but, it is not in the predicted direction. Contrary to my predictions (Hypotheses 19 and 20), having either parent in a science-related occupation deters students from majoring in science. As Table 7 shows, having a father in science (B=-0.92) significantly reduces the probability of majoring in science and so does having a mother in science (B=-1.05). The results from Table 8 show that having a father or mother in science decreases the likelihood of majoring in science by 60% and 65% respectively.

<u>High School Experiences</u>

The results reported in Table 7 show that, as predicted (Hypothesis 21), students with more mathematics preparation (B=0.84) are more likely to major in science. Expressed in the percentage odds of Table 8, this means that the likelihood of majoring in science is increased by 131% for students who have high levels of mathematics preparation. Having more science preparation, however, does not affect the decision to pursue science. Hypothesis 22 was not supported. There was support for Hypothesis 23, however. Table 7 shows that students with higher grades in mathematics and science (B=0.30) are more likely to major in science. Having high grades increases the likelihood of majoring in science by 35%.

<u>Student Interests</u>

Table 7 shows that having greater interest in science (B=0.86) (Hypothesis 24) and wanting a career in science (B=1.79) (Hypothesis 25) both significantly increase the likelihood of majoring in science. And Table 8 makes clear that the former increases the probability of majoring by 135% and the latter by 550%. Hypothesis 26 was not

Table 6: Summary of Hypotheses for Predicting the Probability of Majoring in Science for Model One* (N=248)

	Predicted Direction
Family Background	
Father's Education (H.17)	+
Mother's Education (H.18)	+
Father in Science (H.19)	+
Mother in Science (H.20)	+
High School Experiences	
Math Preparation (H.21)	+
Science Preparation (H.22)	+
Math/Science Grade (H.23)	+
Student Interests	
Interest in Science (H.24)	+
Career Aspirations (H.25)	+
Working with People (H.26)	-
Sex-Role Attitudes	
Global (H.27)	
Science-Specific (H.28)	+
Intellectual Orientation	
Precise Answers (H.29)	+
Science Self-Efficacy(H.30)	+
Math Self-Efficacy (H.31)	+
Encouragement (H.32)	+

* These hypotheses correspond to those discussed in Chapter Three.

Table 7: Results of the Logistic Regression Analysis Predicting the Likelihood of Majoring in Science for Model One (N=248)

	(B)
Family Background	
Father's Education (H.17)	0.11
Mother's Education (H.18)	-0.07
Father in Science (H.19)	-0.92*
Mother in Science (H.20)	-1.05*
High School Experiences	
Math Preparation (H.21)	0.84**
Science Preparation (H.22)	0.08
Math/Science Grade (H.23)	0.30*
Student Interests	
Interest in Science (H.24)	0.86***
Career Aspirations (H.25)	1.80***
Working with People (H.26)	-0.01
Sex-Role Attitudes	
Global (H.27)	0.54**
Science-Specific (H.28)	0.37*
Intellectual Orientation	
Precise Answers (H.29)	0.88***
Science Self-Efficacy (H.30)	1.20***
Math Self-Efficacy (H.31)	-0.29
Encouragement (H.32)	0.48***
Gender (Male)	1.56***
Constant	-14.49***
-2 Log Likelihood	138.45***
Model X^2	201.21***
Pseudo R^2	0.59

* p<.10; **p<.05; ***p<.01 for one-tailed tests.

Table 8: Probability Estimates for Model One (N=248)

	Probability Estimate (in percent)
Family Background	
Father's Education	12
Mother's Education	7
Father in Science	60*
Mother in Science	65*
High School Experiences	
Math Preparation	131**
Science Preparation	7
Math/Science Grade	35*
Student Interests	
Interest in Science	136***
Career Aspirations	500***
Working with People	2
Sex-Role Attitudes	
Global	71**
Science-Specific	45*
Intellectual Orientation	
Precise Answers	141***
Science Self-Efficacy	233***
Math Self-Efficacy	26
Encouragement	62***
Gender (Male)	376**

* p<.10; **p<.05; ***p<.01 for one-tailed tests.

supported. The coefficient for working with people (B=-0.01) was in the predicted direction but it is not statistically significant.

Sex-Role Attitudes

Table 7 shows that global (B=0.54) and science-specific sex-role attitudes (B=0.37) both have statistically significant effects on the probability of majoring in science. The probability estimates from Table 8 mean that the probability of majoring in science increases by 71% for respondents with more traditional global sex-role attitudes. The results for science-specific sex-role attitudes support Hypothesis 28. The likelihood of majoring in science for respondents who strongly believe that society encourages women to pursue science is increased by 45%.

Intellectual Orientation

Consistent with Hypothesis 29, students who prefer material with precise answers (B=0.88) are more likely to major in science than students who do not have this preference. This preference increases the likelihood of majoring in science by 141% as shown in Table 8. The results for Model One also support Hypothesis 30. The more science self-efficacy (B=1.20) students have, the more likely they are to pursue an undergraduate major in science. According to the probability estimates in Table 8, the likelihood of majoring in science is increased by 233% when students feel that they are competent in science. The results do not support my hypothesis (31), that having math self-efficacy increases the likelihood of majoring in science. The results show that mathematics self-efficacy does not have a significant effect (B=-0.29) on the probability of majoring in science.

Encouragement to Pursue Science

The results from Table 7 show that Hypothesis 32 is supported. The more encouragement students receive to pursue science (B=0.48), the more likely they are to major in science. Receiving high levels of encouragement increases the likelihood of majoring in science by 62%.

Gender

Taken together, Tables 7 and 8 show that men are much more likely to major in science than women (B=1.56). To explain more fully the effects of gender on the probability of majoring in science, I now turn to Model Two which includes all the variables in Model One plus the nine gender interactions hypothesized in Chapter Three and summarized in Table 9.

MODEL TWO: PREDICTING THE PROBABILITY OF MAJORING IN SCIENCE TAKING INTO ACCOUNT GENDER INTERACTIONS

As the literature review in Chapter Three makes clear, researchers have argued that the effects of some of the factors that influence the decision to major in science may vary by gender. To investigate this possibility, I used logistic regression to estimate Model Two (with gender interactions). The results presented in Table 10 indicate that the addition of the nine interaction terms in Model Two does not represent a statistically significant improvement over Model One in predicting the probability of students majoring in science. Comparing both the Pseudo R^2s and the Model X^2s for Model One and Two, I found that the Pseudo R^2 increases the model's predictive efficacy from 0.59 (Model One in Table 7) to 0.62 (Model Two in Table 10). This suggests that by including the nine gender interaction terms, Model Two is only marginally better able to predict majoring in science (3%). In addition, the Model X^2s indicates that there is no significant improvement in the fit of the data of Model Two (X^2=209.14) over Model One (X^2=201.21). But as the discussion of Model Two that follows shows, the effects of gender on the probability of majoring in science becomes interesting when each significant gender interaction is considered separately.

<u>Family Background</u>

Four of the gender interactions involve family background characteristics. In all cases, I predicted that their effects would be greater for women than for men

(Hypotheses 17a, 18a, 19a, 20a). None of these predictions was supported. There are no differences in the effects of parental educational attainment or having a parent in a science-related occupation for women and men. When the gender interaction terms are added to Model One, the effect of the education variables remain the same. The mother in science (B=-1.10) variable no longer significantly decreases the likelihood of majoring in science (although it barely fails to meet the significance criterion). Having a father in a science-related career continues to decrease the likelihood of majoring in science.

<u>High School Experiences</u>

I did not hypothesize gender interactions for any of the High School Experience variables. Comparing Model Two (Table 7) with Model One (Table 10) shows that the effects of mathematics preparation, science preparation, and grades are not affected by the inclusion of the gender interaction terms.

<u>Student Interests</u>

No gender interactions were hypothesized for the student interest variables. The effect of interest in science and wanting a career in science remain significant positive predictors of majoring in science in Model Two. My measure of intrinsic job rewards, working with people, remains nonsignificant.

Sex-Role Attitudes

Hypotheses 27a predicted a gender interaction for global sex-role attitudes. I argued that while men with more traditional attitudes will be more likely to major in science, women with more traditional attitudes will be less likely to pursue this undergraduate major. The multiplicative term for this interaction (B=-1.00) is significant in Model Two. I examined the exact nature of this gender interaction, by estimating Model One separately for men and women (analyses not shown). These results show that men (B=-1.88) with more traditional attitudes are significantly less likely to major in science than men with less traditional attitudes. In contrast, women with more traditional attitudes (B=1.06) are significantly more likely to major in science than their female counterparts with less traditional attitudes. These findings are significant but they are in the opposite direction to what I predicted.

The gender interaction for science-specific sex-role attitude is not statistically significant and therefore does not support Hypothesis 28a. This means that the impact of believing that society encourages women to pursue science is the same for men and women. But as Table 10 shows, when I added the gender interaction terms, its effect (B=0.33) on the probability of majoring in science becomes nonsignificant.

Table 9: Summary of Whether Gender Interactions are Hypothesized for Model Two* (N=248)

	Gender Interaction
Family Background	
Father's Education (H.17a)	Yes
Mother's Education (H.18a)	Yes
Father in Science (H.19a)	Yes
Mother in Science (H.20a)	Yes
High School Experiences	
Math Preparation	No
Science Preparation	No
Math/Science Grade	No
Student Interests	
Interest in Science	No
Career Aspirations	No
Working with People	No
Sex-Role Attitudes	
Global (H.27a)	Yes
Science-Specific (H.28a)	Yes
Intellectual Orientation	
Precise Answers	No
Science Self-Efficacy (H.30a)	Yes
Math Self-Efficacy (H.31a)	Yes
Encouragement (H.32a)	Yes

* These gender interaction hypotheses correspond to those discussed in Chapter Three.

Table 10: Results of the Logistic Regression Analysis with Gender Interactions Terms for Predicting the Likelihood of Majoring in Science for Model Two (N=248)

	(B)
Family Background	
Father's Education (H.17)	0.11
Mother's Education (H.18)	-0.15
Father in Science (H.19)	-1.96**
Mother in Science (H.20)	-1.10
High School Experiences	
Math Preparation (H.21)	0.99**
Science Preparation (H.22)	0.07
Math/Science Grade (H.23)	0.31*
Student Interests	
Interest in Science (H.24)	0.98***
Career Aspirations (H.25)	1.93***
Working with People (H.26)	0.03
Sex-Role Attitudes	
Global (H.27)	1.02
Science-Specific (H.28)	0.33
Intellectual Orientation	
Precise Answers (H.29)	0.98***
Science Self-Efficacy (H.30)	1.84***
Math Self-Efficacy (H.31)	-0.62*
Encouragement (H.32)	0.50**
Gender (Male)	4.62
Multiplicative Terms (Gender Interactions)	
Father's Education * Gender (H.17a)	0.08
Mother's Education * Gender (H.18a)	0.14
Father in Science * Gender (H.19a)	1.46
Mother in Science * Gender (H.20a)	-0.23
Global * Gender (H.27a)	-1.00**a
Science-Specific * Gender (H.28a)	0.09
Science Self-Efficacy * Gender(H.30a)	-1.21*a
Math Self-Efficacy * Gender (H.31a)	0.68
Encouragement * Gender (H.32a)	0.14
Constant	-17.03***
-2 Log Likelihood	130.52***
Model X^2	209.14***
Pseudo R^2	0.62

a indicates gender interaction that is statistically significant at 0.10.

* p<.10; **p<.05; ***p<.01 for one-tailed tests.

Intellectual Orientation

I did not hypothesize gender interactions for intellectual style. In Model Two having a preference for material with precise answers continues to significantly increase the probability of majoring in science.

Hypotheses 30a and 31a both predict that the positive effects of self-efficacy will be greater for women than for men. Only the hypothesis (30a) for science self-efficacy was supported (B=-1.21). To interpret this gender interaction, I estimated Model One separately for men and women (analyses not shown). These results show that greater science self-efficacy increases the likelihood of majoring in science for both genders, but that the effect is stronger for women (B=1.77) than for men (B=1.30). There is no gender difference in the effects of mathematics self-efficacy (B=0.68). But now mathematics self-efficacy decreases the probability of majoring in science (B=-0.62) -- a finding that contradicts the prediction laid out in Hypothesis 31.

Encouragement to Pursue Science

The literature suggests the positive effect of encouragement to pursue science on the probability on majoring in science should be greater for women than for men (Hypothesis 32a). Table 10 shows that the multiplicative terms for this gender interaction (B=0.14) is not significant. The effect of encouragement to pursue science is the same for men and women. The more encouragement they receive to major in science, the more likely they are to major in science, regardless of their gender.

The results of the statistical analyses show that Model Two (with gender interactions) does not provide a better fit of the data than Model One (without gender interactions). This means that by adding gender interactions the predictive power of the overall model is not significantly improved. Model One established which variables predict the likelihood of majoring in science. Level of interest in aspiring to a career in science, gender, science self-efficacy, preference for material with precise answers, interest in science and mathematics preparation were the best predictors according to Table 8. Model Two tested to see if the effects of nine of the variables included in Model One were dependent on the gender of the student. Only two of the gender interaction terms were statistically significant, global sex-role attitudes and science self-efficacy. The effects of the other variables in the model are the same for men and women.

CHAPTER SIX:

DISCUSSION AND CONCLUSION

The specific objectives of this study were to identify: (1) differences that exist between science and social science students and (2) factors that predict the probability of majoring in science. This chapter highlights key findings from both sets of analyses and explores their implications for future research on the science pipeline.

SCIENCE-SOCIAL SCIENCE COMPARISONS

I constructed sixteen hypotheses to explore the differences between science and social science students. Thirteen were supported. The three hypotheses that were not supported all fell in the category of family background characteristics. Contrary to my predictions, science majors were not more likely to have fathers or mothers in science but they were more likely to have fathers with more education. The other eleven differences I found were consistent with the predictions derived from the four strands of research on academic choices. Taken together, they support arguments that science and social science majors differ in their family background, high school experiences, interests, sex-role attitudes, intellectual orientations and levels of encouragement to pursue science. But what implications do these differences have for predicting the probability of majoring in science? My results show that significant differences in the levels of these factors (Table 5) do not necessarily translate into significant effects on the probability of majoring in science. For Model One (Table 7), father's education, science preparation, and working with people do not have significant effects on the probability of majoring in science. As well, just because science and social science majors did not differ in the levels of the other factors, this did not mean these factors were unimportant in terms of affecting the probability of majoring in science. Having a father in science and global sex-role attitudes did not differentiate science from social science majors but both have significant effects on the probability of majoring in science. Because these patterns also hold for Model Two (Table 10), my results highlight the importance of developing and testing models that predict the probability of majoring in science.

FACTORS INFLUENCING THE SELECTION OF AN UNDERGRADUATE SCIENCE MAJOR

To explore the factors that lead undergraduate students to select a science major, I developed and tested models without gender interactions (Model One) and with gender interactions (Model Two). Because the inclusion of the gender interactions did not improve the overall fit of the model, I limit my discussion of Model Two to the two significant gender interactions. For Model One, I identify the most important predictors based on the results found in Table 8 and then discuss the unexpected findings. The importance of gender will be addressed in my discussion of the gender interaction hypotheses later in this chapter.

Model One (Without Gender Interactions)

The findings for Model One show that the most important factors that predict the probability of majoring in science are, in descending order of importance: science career aspirations, gender, science self-efficacy, preference for material with precise answers, interest in science, and mathematics preparation. These findings support earlier calls for taking into consideration interests, intellectual orientations and high school experiences when examining academic choices of undergraduates. They suggest that the decision to major in science is influenced largely by the characteristics of individuals; that is, by their interests (science career aspirations and interest in science) and intellectual orientations (preference for material with precise answers and science self-efficacy). Because interests and orientations develop over time and through interactions with others, these results highlight the importance of taking seriously the temporal and contextual elements of the science pipeline. The importance of mathematics preparation reinforces calls for the inclusion of high school experiences in studies examining outcomes at later points in the science pipeline. My results also highlight the importance of pre-high school decisions. Addressing such questions as: "At what point along the science pipeline do interests and orientations form?" and "When do career interests become important in determining student behaviour?" may improve our understanding of the factors that lead men and women to pursue science.

Turning to the contextual element of the pipeline, all four strands of research on academic choices have stressed the importance of receiving encouragement from others to pursue science. Following them, I predicted and found that the more encouragement to pursue science students received, the more likely they were to major in science. Although encouragement to pursue science was not one of my best predictors, this finding is interesting because much of the previous research has focused on the importance of encouragement for women. I found the same effect for a sample that also includes men.

The importance of context is also evident in the significant positive effect that my measure of science-specific sex-role attitudes had on the probability of majoring in science. If the broader social context is important, as the contextual element of the pipeline suggests, then the more students believe that society encourages women to pursue science the more likely they are to major in science. This is exactly what I found.

This analysis also produced some surprising results. I predicted that father's educational attainment and mother's educational attainment, science preparation, and mathematics self-efficacy would all increase the likelihood of majoring in science. I also predicted that the desire to work with people would decrease the probability of majoring in science. None of these variables had a significant effect on the probability of majoring in science.

Family background characteristics have consistently been shown to predict the probability of majoring in science. In my model, however, the effects of father's educational attainment and mother's educational attainment were both nonsignificant. These results support arguments (Haertal et al.,1981; Ware et al.,1985) that parents' education *per se* may be less important than the opportunities and benefits available to children that are conventionally associated with parents who have high levels of educational attainment. Not only do highly educated parents have more encyclopedias and home computer systems, but also they are more likely to provide special tutoring and enrichment programmes that further their child's interest in science. What this line of argument suggests, then, is that more work should be conducted done on the science-related correlates of parents' high educational attainment and their impact on choice of undergraduate major.

All four strands of research emphasize the importance of high school experiences and, in particular, preparation and achievement in science and mathematics. My results are consistent with their findings, with one exception: Science preparation did not have a significant effect on the probability of majoring in science. This was not the case for science self-efficacy, however. In Model One science self-efficacy had a significant positive effect on the probability of majoring in science. Because I found the opposite pattern for the mathematics preparation and mathematics self-efficacy variables, my research points to the importance of exploring more fully the relationship between students' objective and subjective assessments of aptitude for science and mathematics.

Some researchers have explored the impact of job rewards on academic choices (Lips, 1992; Pathways Project, 1993). Unlike them, I did not find that students who value working with people were less likely to major in science. The nonsignificant effect of this variable may reflect a growing realization that having a career in science does not preclude working with people. It may also reflect the limitations of the extrinsic-intrinsic dichotomy that informs most research on job values inside and outside the science context. Results from recent work that differentiates between altruistic and social rewards (e.g., by Marini, Fan, Finley, and Beutal, 1996), as opposed to simply intrinsic and extrinsic rewards, raises the question of whether measures tapping these work values would be better predictors of pursuing science.

Researchers in the Men and Women in Science strand have found that having one or both parents in science-related occupations increases the likelihood of pursuing a science major. I found the opposite effect. Rather than increasing the likelihood of majoring in science, having either parent in a science-related career deterred students form pursuing science in university. Parents in science may "demystify" the world of science for their children as Nevitte et al. (1988) suggest. By providing a realistic picture of science as a particularly demanding career involving long hours in a competitive environment (Frieze et al.,1984; Lips, 1992; Pathways Project, 1993; Steinkamp and Maehr, 1984) this "demistification" may discourage students from pursuing science. Shifting the focus from whether or not students have parents in science-related occupations to what they actually learn from their parents about careers in science may help to clarify the effect of parents' occupations on choice of undergraduate major.

The positive effect of global sex-role attitudes in Model One was also surprising. I predicted that the effects of this variable would be gender-specific. Because this gender interaction was significant in Model Two, I now turn to this model and, discuss the importance of gender.

Model Two (With Gender Interactions)

In my specifications of Model Two I argued that the effects of global sex-role attitudes on the probability of majoring in science would be different for men and women. Men with more traditional sex-role attitudes were expected to be more likely to major in science: women with more traditional sex-role attitudes were expected to be less likely to major in science. I did find gender-specific effects but, they contradicted my predictions. Men with less traditional sex-role attitudes were found to be more likely to pursue science and that women with more traditional attitudes were found to be more likely to pursue science.

It is suggested here that these contradictory findings may be an artifact of my measure of global sex-role attitudes. Following the Pathways Project (1993), I based my measure on the work of Mason, Czajka, and Arber (1976). Their items may have worked well for women in the 1970s when men were expected to be breadwinners and "the priority [for women] was placed on marriage and motherhood--leaving little time for responsible careers as scientist, engineer, or doctor, except for those rare Amazons among us who can live two lifetimes in one" (Rossi, 1965 as cited in Morgan, 1992:228). But, as recent research makes clear, there is a "new cultural imperative" for women and men to combine career and family roles in their adult lives (Fassinger, 1990). It is not surprising, then, that over 80% of my respondents expressed nontraditional sex-role attitudes. Using items that tap the new cultural imperative should improve our understanding of the effects of global sex-role attitudes on the probability of majoring in science.

The only other gender interaction that was significant in Model Two involved science self-efficacy. As predicted, science self-efficacy increased the probability of majoring in science for both men and women but its effect was stronger for women. What my test of Model Two suggests, then, is that gender may not be as important an influence on the decision to major in science as some researchers have claimed. Seven of the nine gender interactions in Model Two were nonsignificant. In my study, the effects of family background, science-specific sex-role attitudes, math self-efficacy, and encouragement to pursue science are the same for men and women. It is not surprising, then, that Model Two was not a significant improvement over Model One.

This does not mean that gender is unimportant, however. It did predict the probability of majoring in science in Model One. To explore more fully its potential effects, other gender interactions may be explored in order to determine whether other factors operate differently for men and women in influencing their decision to major in science.

For example, none of the high school experiences or student interest variables were tested for gender differences in effects in the probability of majoring in science. These experiences and interests are determined earlier on in the pipeline and are likely influenced by contextual factors stemming from the gender socialization process. Future research may examine if, in fact, the impact of high school experiences and interests does differ for male and female students. Future research should also re-examine gender interactions with global sex-role attitudes and encouragement to pursue science using improved measures of the former and source-specific measures of the latter.

Concluding Remarks

Some researchers studying the science pipeline have examined the differences between science and social science majors. Others have explored factors that influence the decision to major in science. I used insights from four strands of research on the decision to pursue science to do both. Because differences in levels do not necessarily translate into significant effects, my results highlight the importance of moving beyond studying differences between science and social science majors to developing models that predict the probability of majoring in science. They also point to the importance of considering factors from all four strands of research on academic choices and, therefore, to the importance of testing these models with data on men and women in science and nonscience fields. Finally, the pipeline analogy clearly shows the importance of considering temporal and contextual effects in studies of academic choice. Following these leads may improve our understanding of the factors that influence men and women to pursue science. Gaining this understanding is essential for developing and maintaining the pool of scientists that are necessary for Canada to remain competitive at the global level.

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